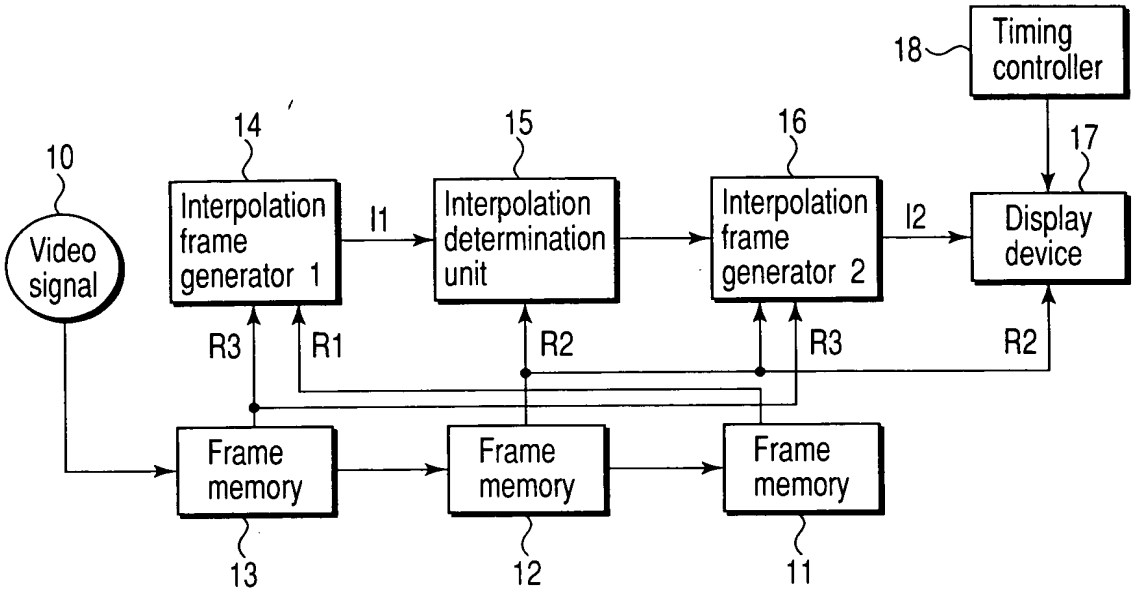
Timing controller
18
17
14
15
16
10
Video signal
Interpolation frame generator 1
I1
Interpolation determination unit
Interpolation frame generator 2
I2
Display device
R3
R1
R2
R3
R2
Frame memory
Frame memory
Frame memory
13
12
11

FIG. 1

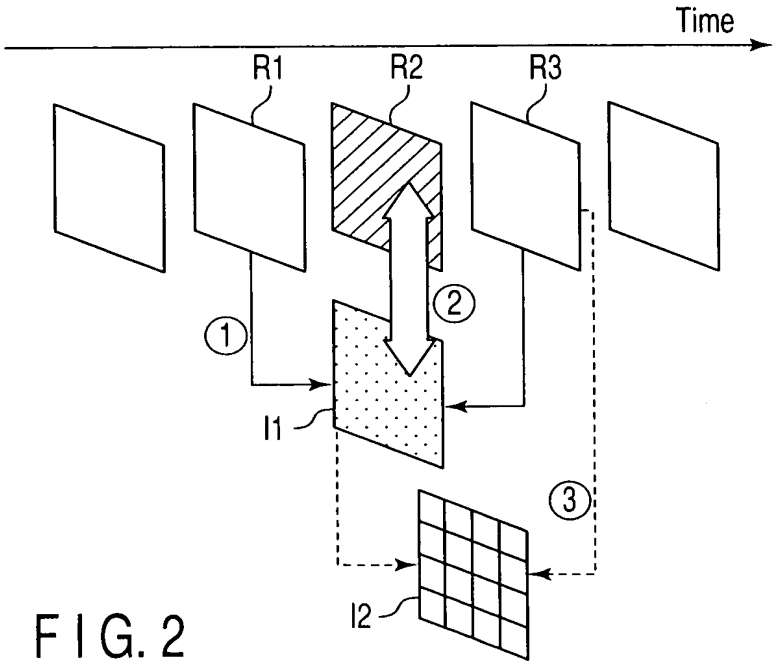
Time
R1
R2
R3
①
②
③
I1
I2

FIG. 2

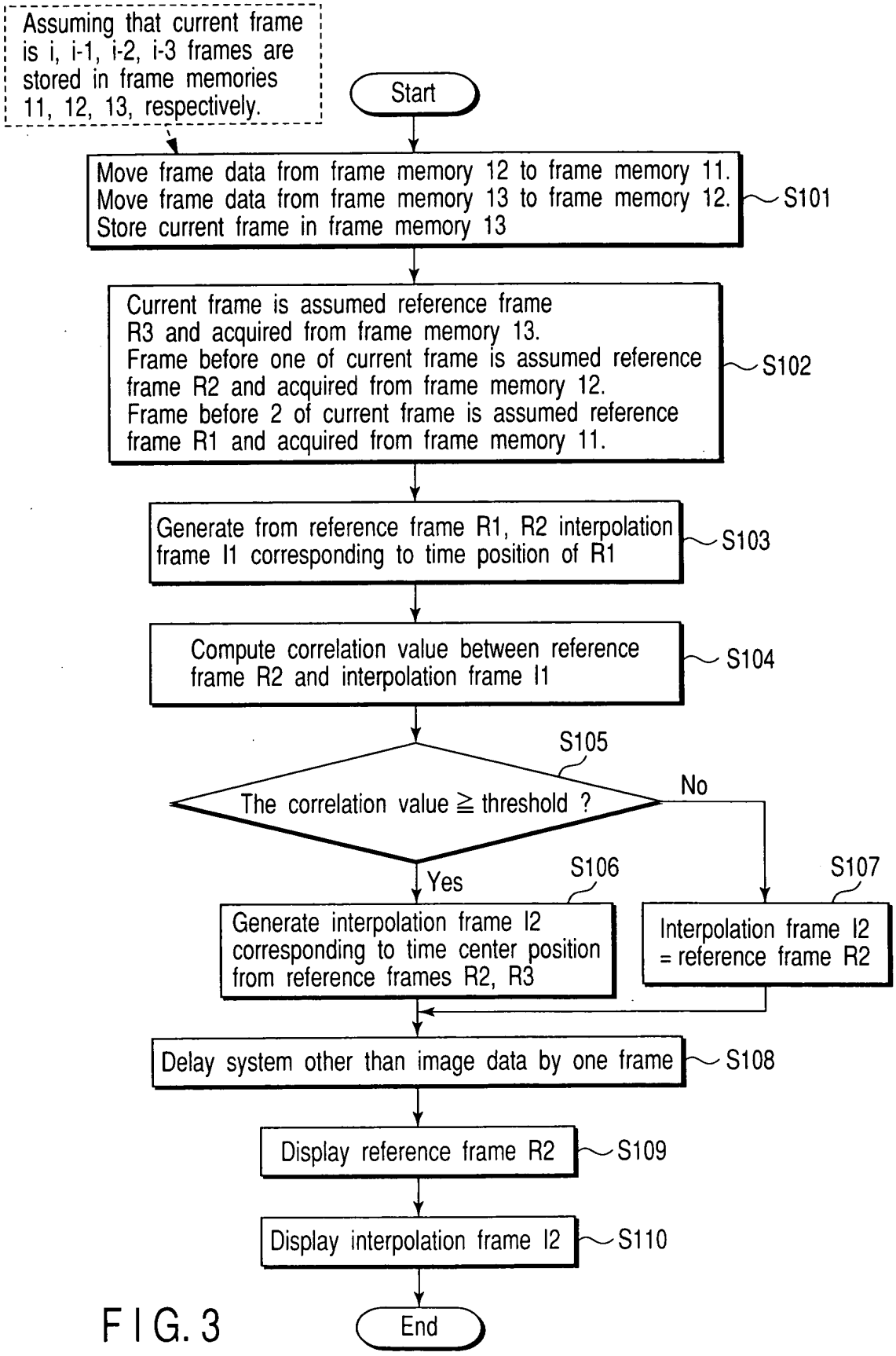
Assuming that current frame is i, i-1, i-2, i-3 frames are stored in frame memories 11, 12, 13, respectively.
Start
Move frame data from frame memory 12 to frame memory 11.
Move frame data from frame memory 13 to frame memory 12.
Store current frame in frame memory 13
S101
Current frame is assumed reference frame R3 and acquired from frame memory 13.
Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12.
Frame before 2 of current frame is assumed reference frame R1 and acquired from frame memory 11.
S102
Generate from reference frame R1, R2 interpolation frame I1 corresponding to time position of R1
S103
Compute correlation value between reference frame R2 and interpolation frame I1
S104
S105
The correlation value ≧ threshold ?
No
Yes
S106
Generate interpolation frame I2 corresponding to time center position from reference frames R2, R3
S107
Interpolation frame I2 = reference frame R2
Delay system other than image data by one frame
S108
Display reference frame R2
S109
Display interpolation frame I2
S110
End

FIG. 3

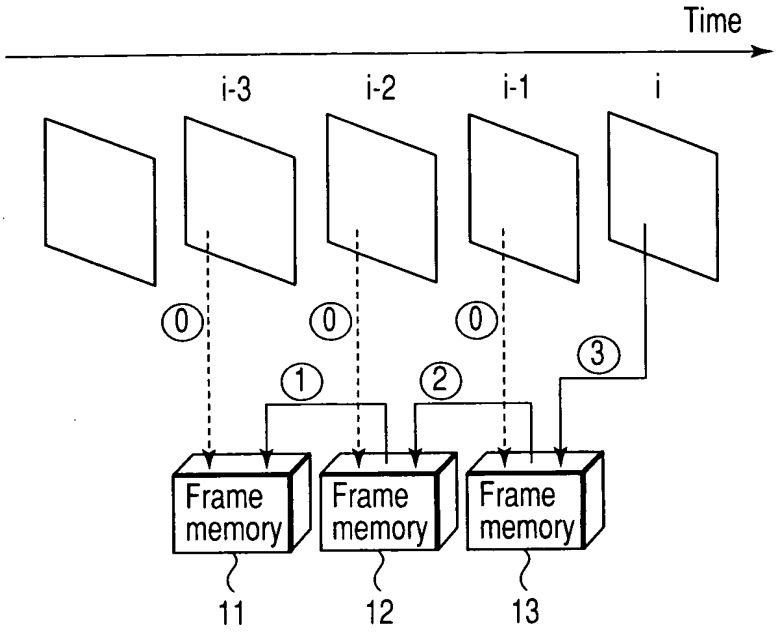
Time
i-3
i-2
i-1
i
0
0
0
3
1
2
Frame memory
Frame memory
Frame memory
11
12
13

FIG. 4

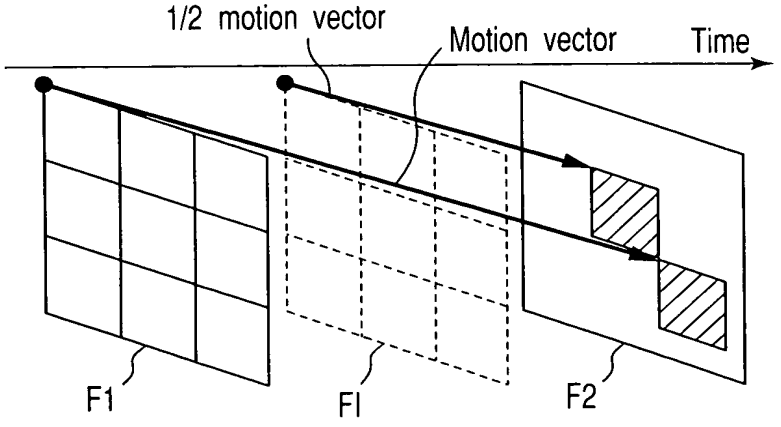
1/2 motion vector
Motion vector
Time
F1
FI
F2

FIG. 5

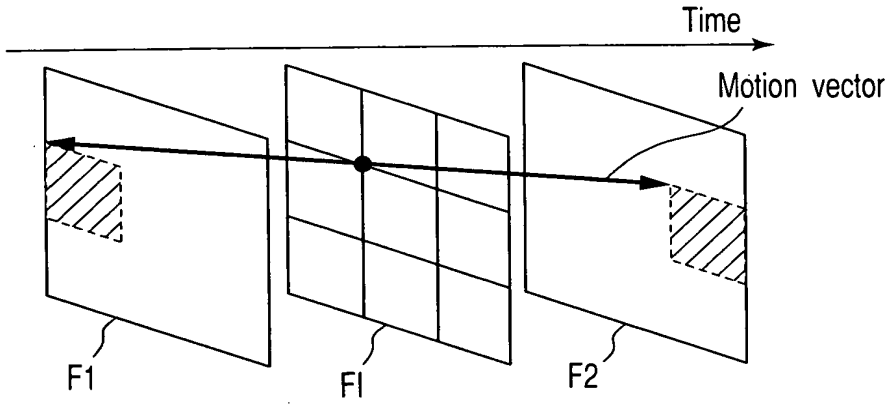
Time
Motion vector
F1
Fl
F2

FIG. 6

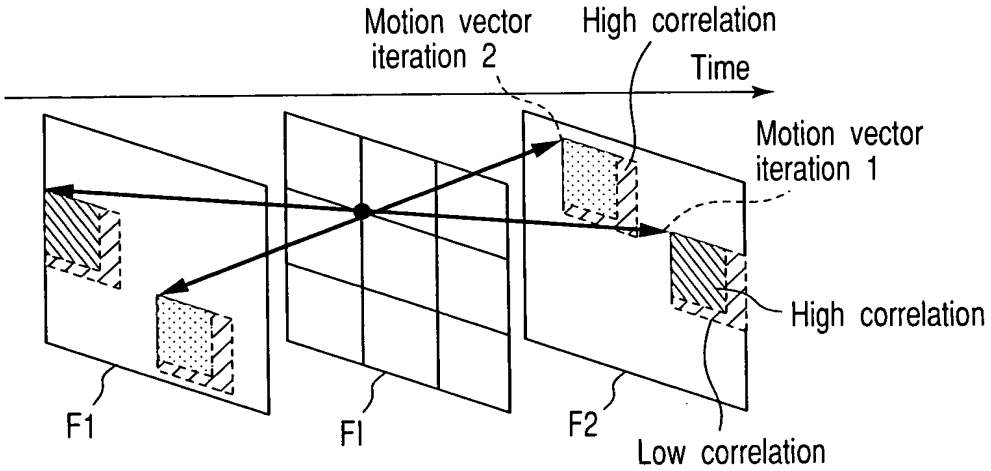
Motion vector
iteration 2
High correlation
Time
Motion vector
iteration 1
High correlation
F1
Fl
F2
Low correlation

FIG. 7

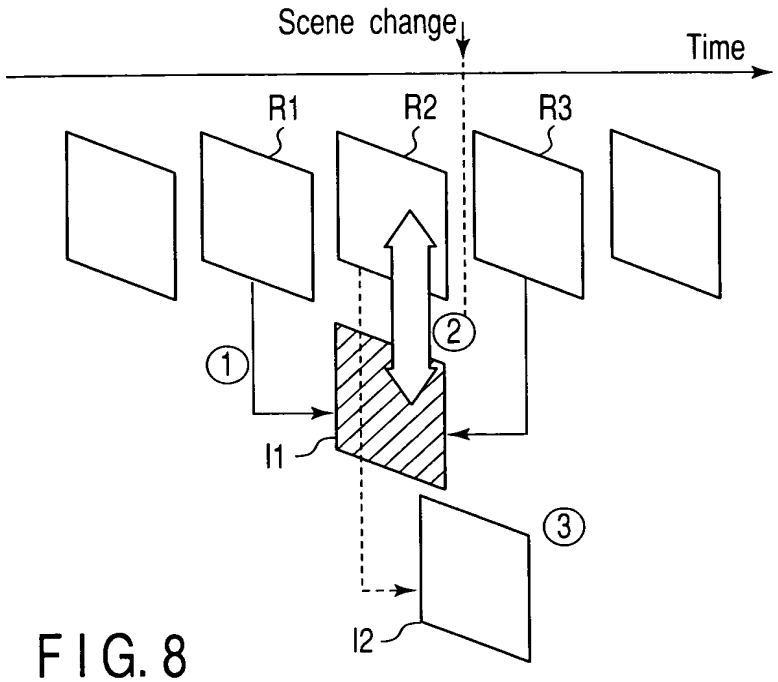
Scene change
Time
R1
R2
R3
①
②
③
I1
I2

FIG. 8

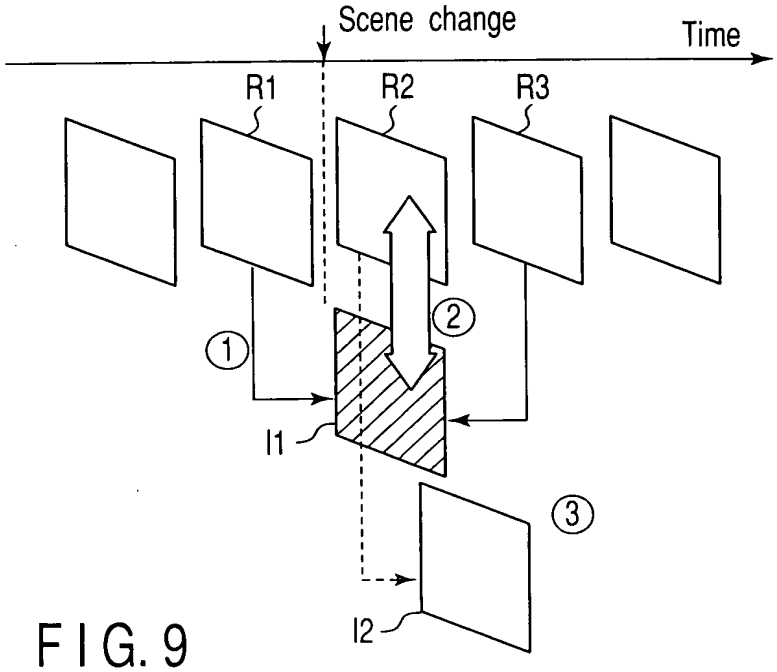
Scene change
Time
R1
R2
R3
①
②
③
I1
I2

FIG. 9

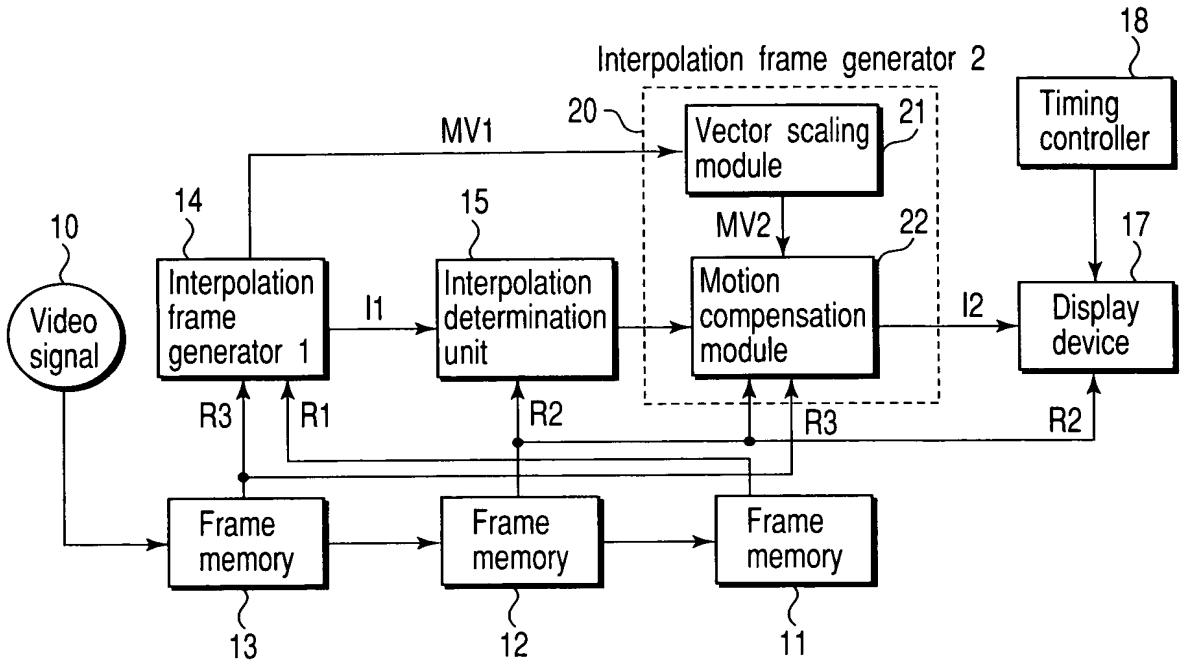
Interpolation frame generator 2
18
Timing controller
20
Vector scaling module
21
MV1
MV2
22
14
15
10
17
Video signal
Interpolation frame generator 1
I1
Interpolation determination unit
Motion compensation module
I2
Display device
R3
R1
R2
R3
R2
Frame memory
Frame memory
Frame memory
13
12
11

FIG. 10

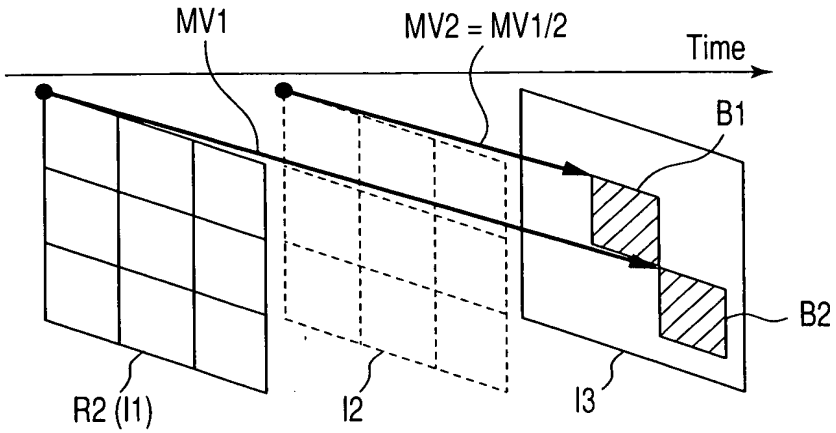
MV1
MV2 = MV1/2
Time
B1
B2
R2 (I1)
I2
I3

FIG. 11

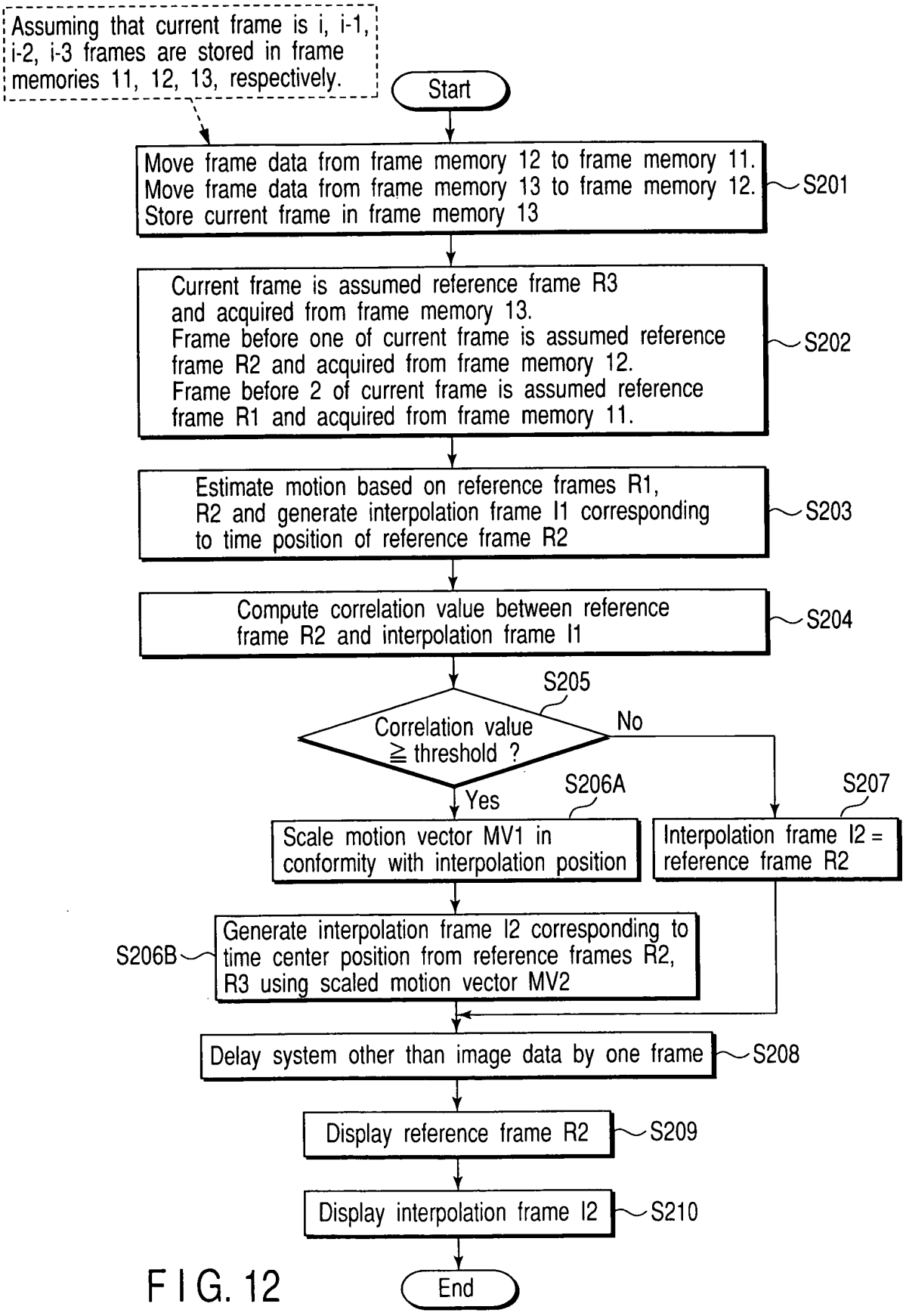
Assuming that current frame is i, i-1, i-2, i-3 frames are stored in frame memories 11, 12, 13, respectively.
Start
Move frame data from frame memory 12 to frame memory 11.
Move frame data from frame memory 13 to frame memory 12.
Store current frame in frame memory 13
S201
Current frame is assumed reference frame R3 and acquired from frame memory 13.
Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12.
Frame before 2 of current frame is assumed reference frame R1 and acquired from frame memory 11.
S202
Estimate motion based on reference frames R1, R2 and generate interpolation frame I1 corresponding to time position of reference frame R2
S203
Compute correlation value between reference frame R2 and interpolation frame I1
S204
S205
Correlation value ≧ threshold ?
No
Yes
S206A
Scale motion vector MV1 in conformity with interpolation position
S207
Interpolation frame I2 = reference frame R2
S206B
Generate interpolation frame I2 corresponding to time center position from reference frames R2, R3 using scaled motion vector MV2
Delay system other than image data by one frame
S208
Display reference frame R2
S209
Display interpolation frame I2
S210
End

FIG. 12

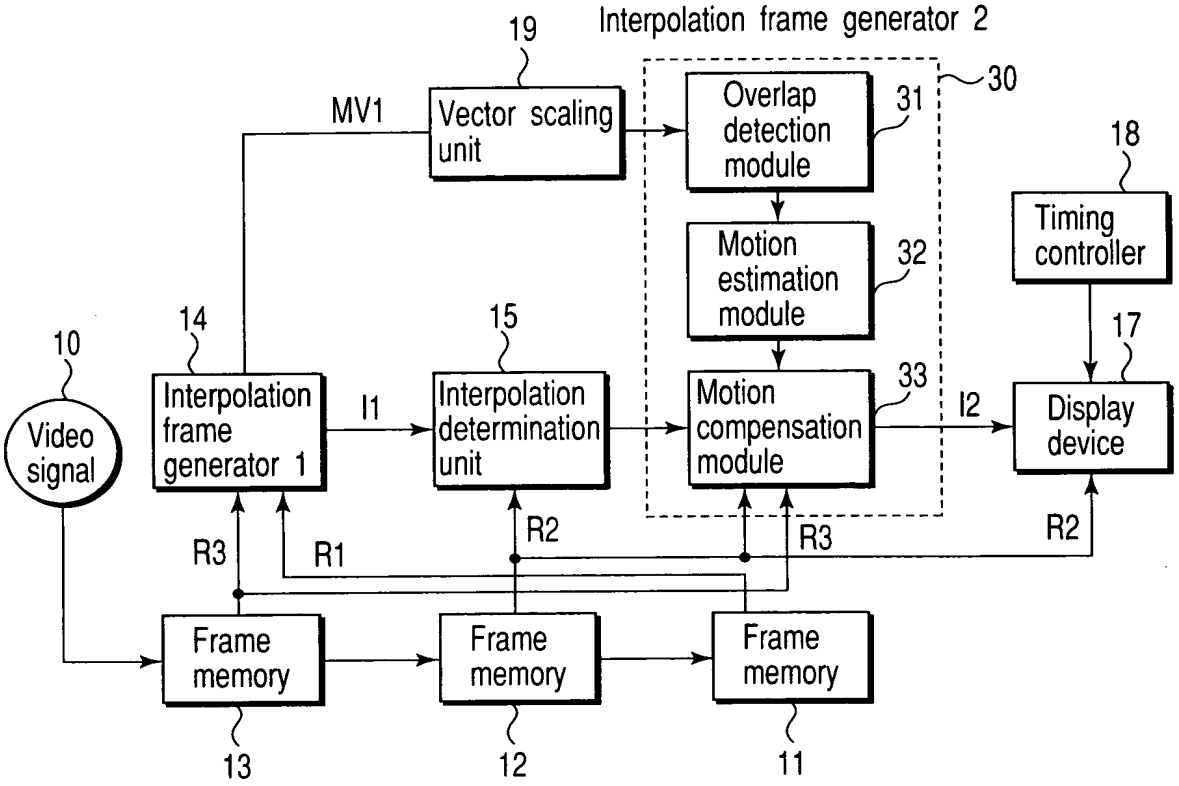
Interpolation frame generator 2
19
30
MV1
Vector scaling unit
Overlap detection module
31
18
Timing controller
Motion estimation module
32
14
15
17
10
33
Interpolation frame generator 1
I1
Interpolation determination unit
Motion compensation module
I2
Display device
Video signal
R3
R1
R2
R3
R2
Frame memory
Frame memory
Frame memory
13
12
11

FIG. 13

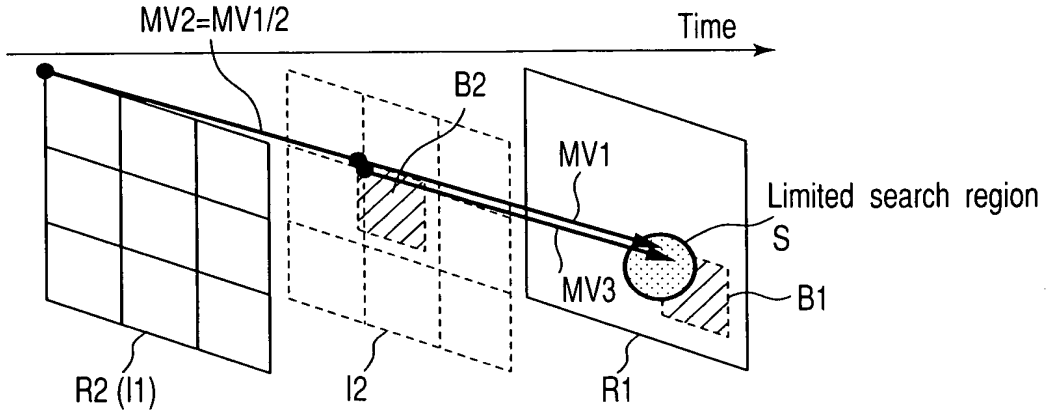
MV2=MV1/2
Time
B2
MV1
Limited search region
S
MV3
B1
R2 (I1)
I2
R1

FIG. 14

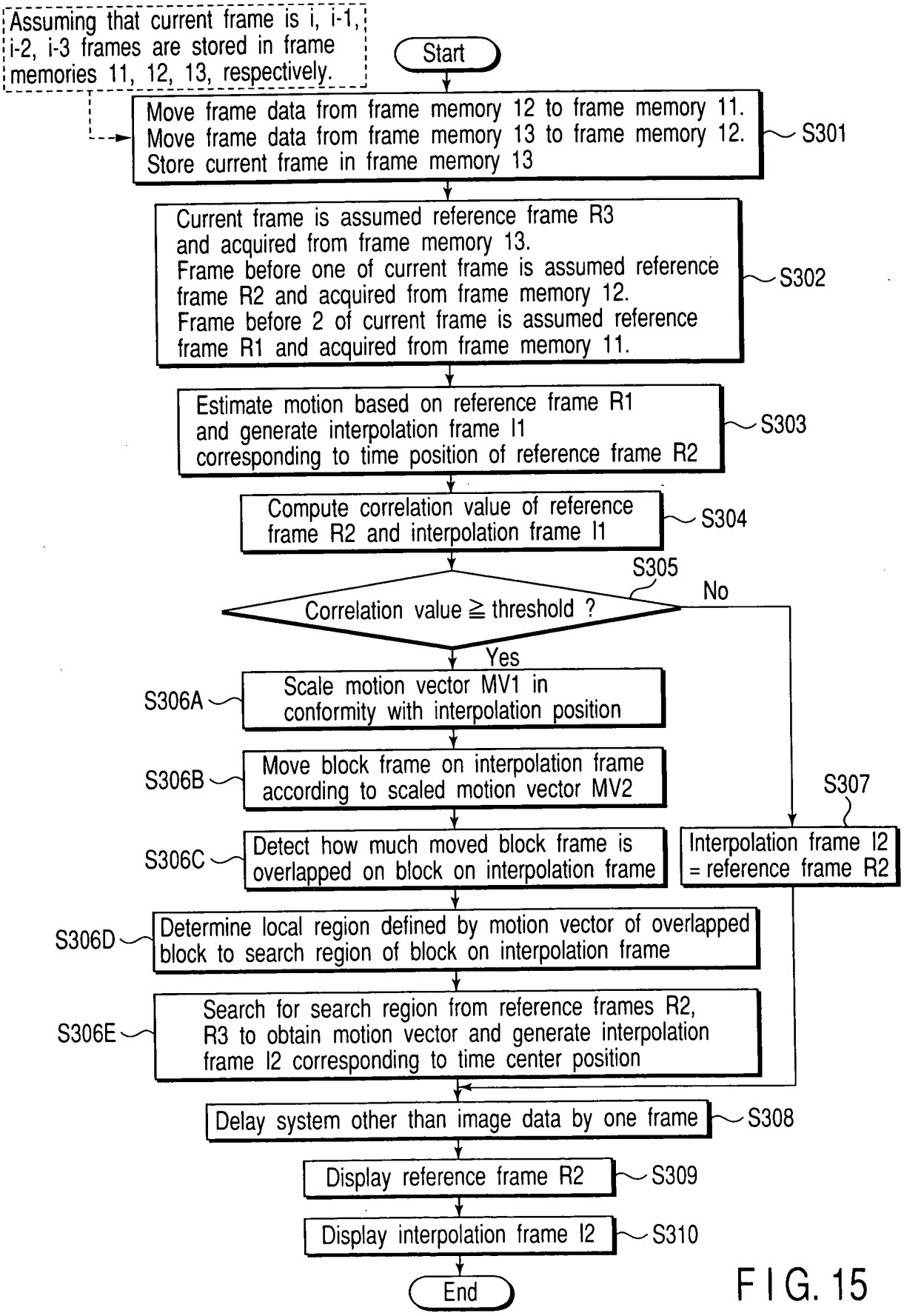
Assuming that current frame is i, i-1, i-2, i-3 frames are stored in frame memories 11, 12, 13, respectively.
Start
Move frame data from frame memory 12 to frame memory 11.
Move frame data from frame memory 13 to frame memory 12.
Store current frame in frame memory 13
S301
Current frame is assumed reference frame R3 and acquired from frame memory 13.
Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12.
Frame before 2 of current frame is assumed reference frame R1 and acquired from frame memory 11.
S302
Estimate motion based on reference frame R1 and generate interpolation frame I1 corresponding to time position of reference frame R2
S303
Compute correlation value of reference frame R2 and interpolation frame I1
S304
S305
Correlation value ≧ threshold ?
No
Yes
S306A
Scale motion vector MV1 in conformity with interpolation position
S306B
Move block frame on interpolation frame according to scaled motion vector MV2
S306C
Detect how much moved block frame is overlapped on block on interpolation frame
S307
Interpolation frame I2 = reference frame R2
S306D
Determine local region defined by motion vector of overlapped block to search region of block on interpolation frame
S306E
Search for search region from reference frames R2, R3 to obtain motion vector and generate interpolation frame I2 corresponding to time center position
Delay system other than image data by one frame
S308
Display reference frame R2
S309
Display interpolation frame I2
S310
End

FIG. 15

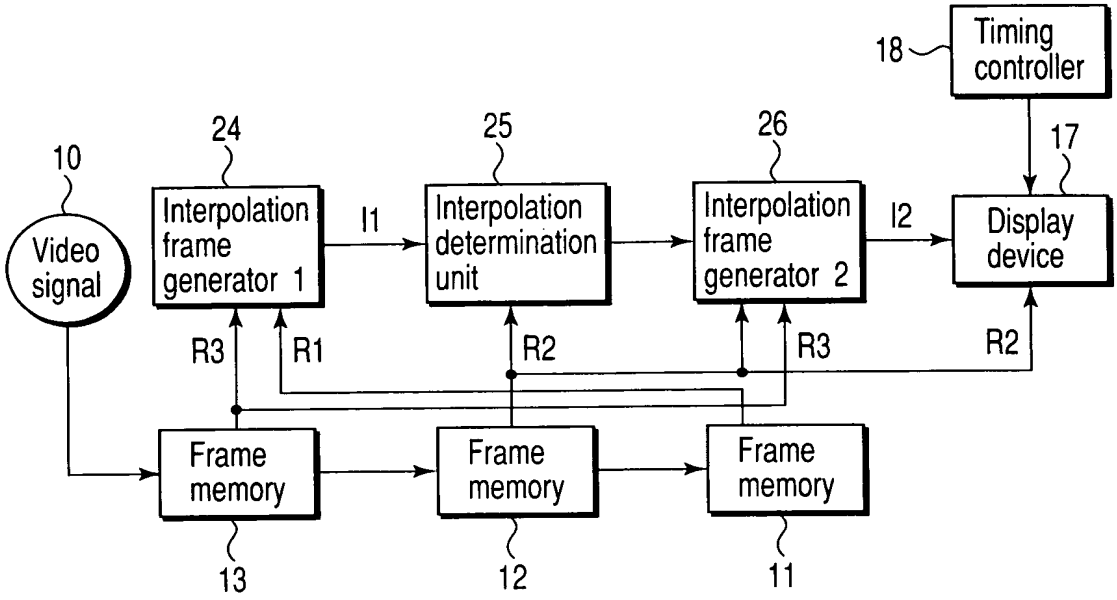
18
Timing controller
17
10
Video signal
24
Interpolation frame generator 1
I1
25
Interpolation determination unit
26
Interpolation frame generator 2
I2
Display device
R3
R1
R2
R3
R2
Frame memory
Frame memory
Frame memory
13
12
11

FIG. 16

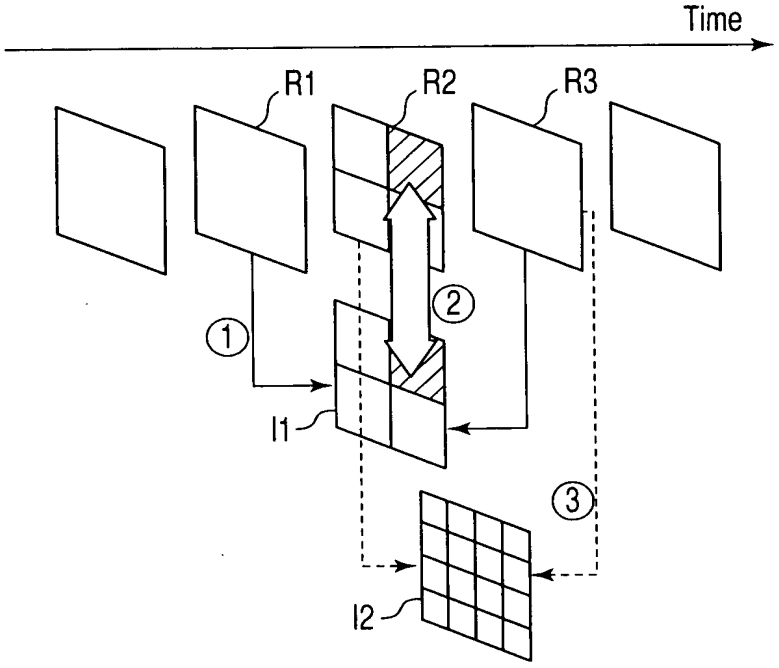
Time
R1
R2
R3
①
②
③
I1
I2

FIG. 17

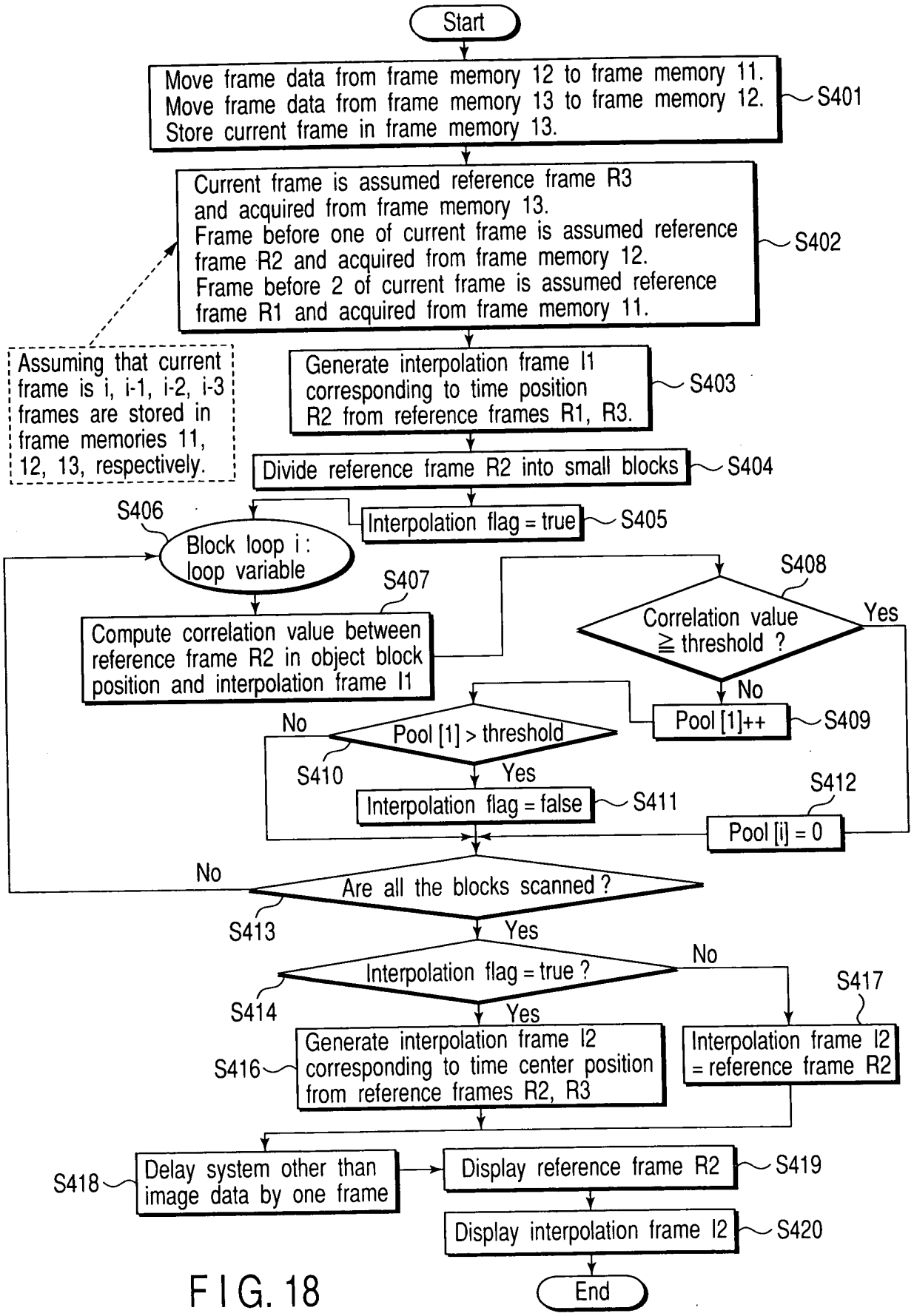
Start
Move frame data from frame memory 12 to frame memory 11.
Move frame data from frame memory 13 to frame memory 12.
Store current frame in frame memory 13.
S401
Current frame is assumed reference frame R3 and acquired from frame memory 13.
Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12.
Frame before 2 of current frame is assumed reference frame R1 and acquired from frame memory 11.
S402
Assuming that current frame is i, i-1, i-2, i-3 frames are stored in frame memories 11, 12, 13, respectively.
Generate interpolation frame I1 corresponding to time position R2 from reference frames R1, R3.
S403
Divide reference frame R2 into small blocks
S404
Interpolation flag = true
S405
S406
Block loop i : loop variable
S407
Compute correlation value between reference frame R2 in object block position and interpolation frame I1
S408
Correlation value ≧ threshold ?
Yes
No
Pool [1]++
S409
No
Pool [1] > threshold
S410
Yes
Interpolation flag = false
S411
S412
Pool [i] = 0
No
Are all the blocks scanned ?
S413
Yes
Interpolation flag = true ?
No
S414
Yes
S417
Generate interpolation frame I2 corresponding to time center position from reference frames R2, R3
S416
Interpolation frame I2 = reference frame R2
S418
Delay system other than image data by one frame
Display reference frame R2
S419
Display interpolation frame I2
S420
End

FIG. 18

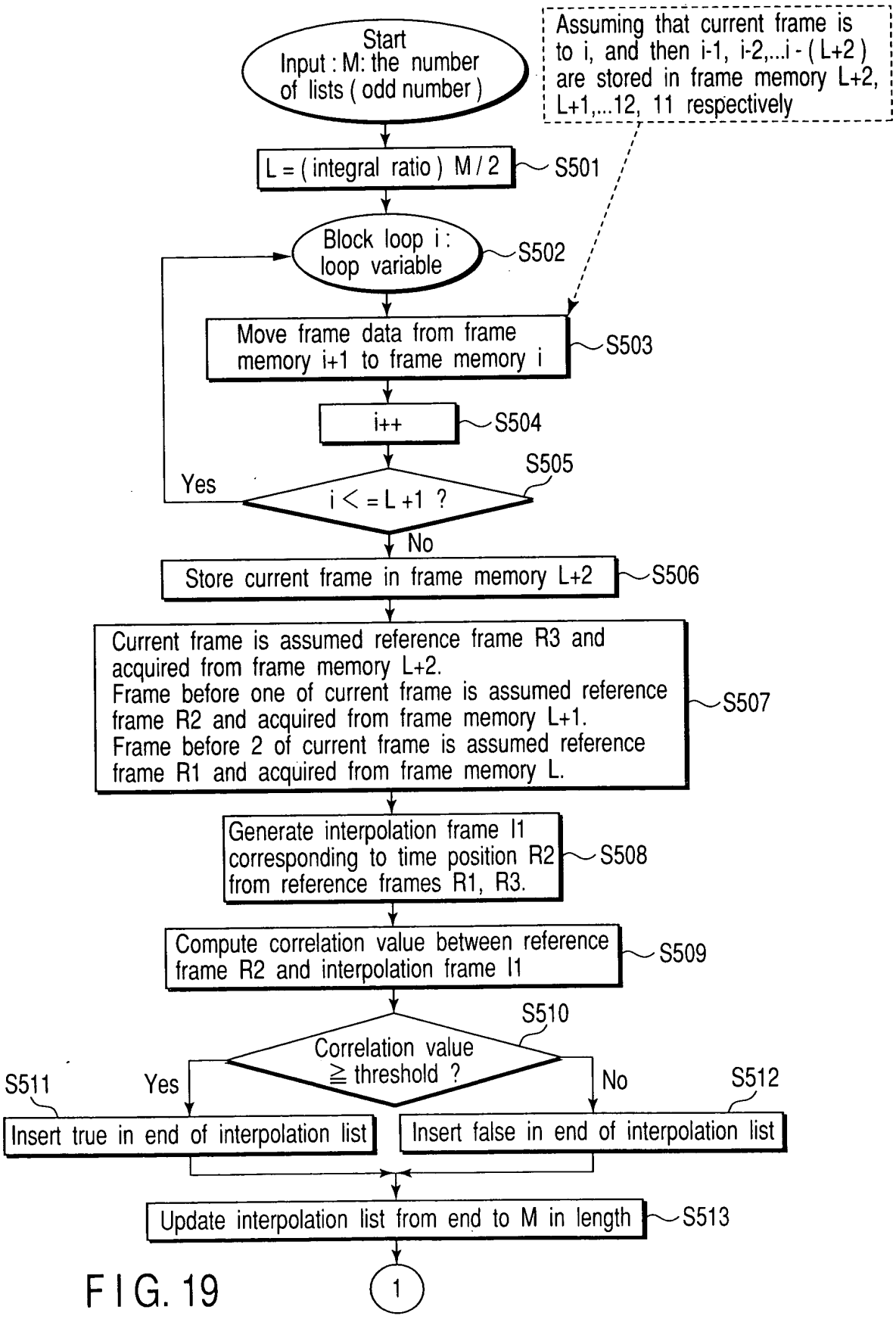
Start
Input : M: the number of lists (odd number)
Assuming that current frame is to i, and then i-1, i-2,...i - (L+2) are stored in frame memory L+2, L+1,...12, 11 respectively
L = (integral ratio) M / 2
S501
Block loop i : loop variable
S502
Move frame data from frame memory i+1 to frame memory i
S503
i++
S504
S505
Yes
i < = L +1 ?
No
Store current frame in frame memory L+2
S506
Current frame is assumed reference frame R3 and acquired from frame memory L+2.
Frame before one of current frame is assumed reference frame R2 and acquired from frame memory L+1.
Frame before 2 of current frame is assumed reference frame R1 and acquired from frame memory L.
S507
Generate interpolation frame I1 corresponding to time position R2 from reference frames R1, R3.
S508
Compute correlation value between reference frame R2 and interpolation frame I1
S509
S510
Correlation value ≧ threshold ?
S511
Yes
No
S512
Insert true in end of interpolation list
Insert false in end of interpolation list
Update interpolation list from end to M in length
S513
1

FIG. 19

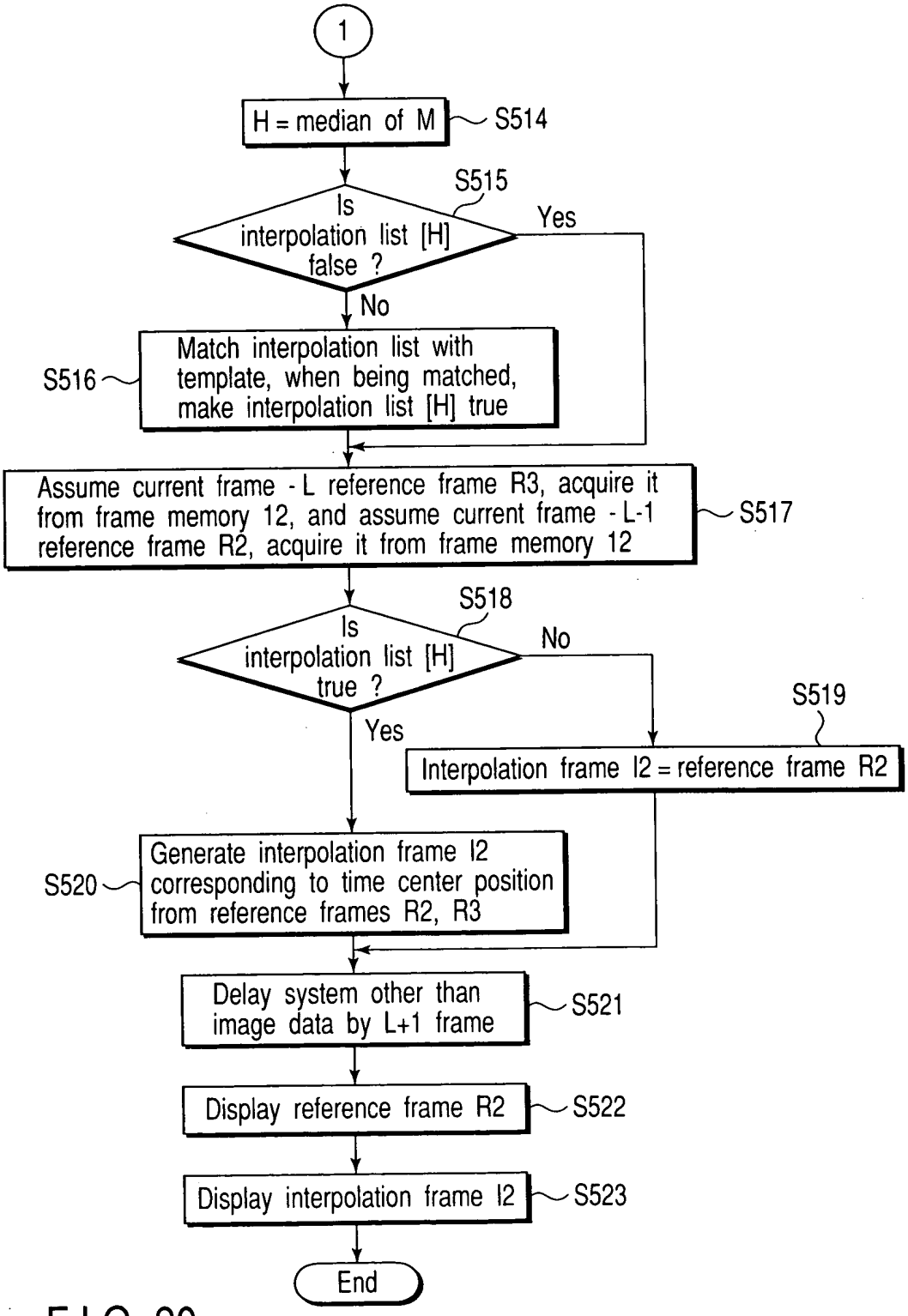
1
H = median of M
S514
S515
Is interpolation list [H] false ?
Yes
No
S516
Match interpolation list with template, when being matched, make interpolation list [H] true
Assume current frame - L reference frame R3, acquire it from frame memory 12, and assume current frame - L-1 reference frame R2, acquire it from frame memory 12
S517
S518
Is interpolation list [H] true ?
No
Yes
S519
Interpolation frame I2 = reference frame R2
S520
Generate interpolation frame I2 corresponding to time center position from reference frames R2, R3
Delay system other than image data by L+1 frame
S521
Display reference frame R2
S522
Display interpolation frame I2
S523
End

FIG. 20

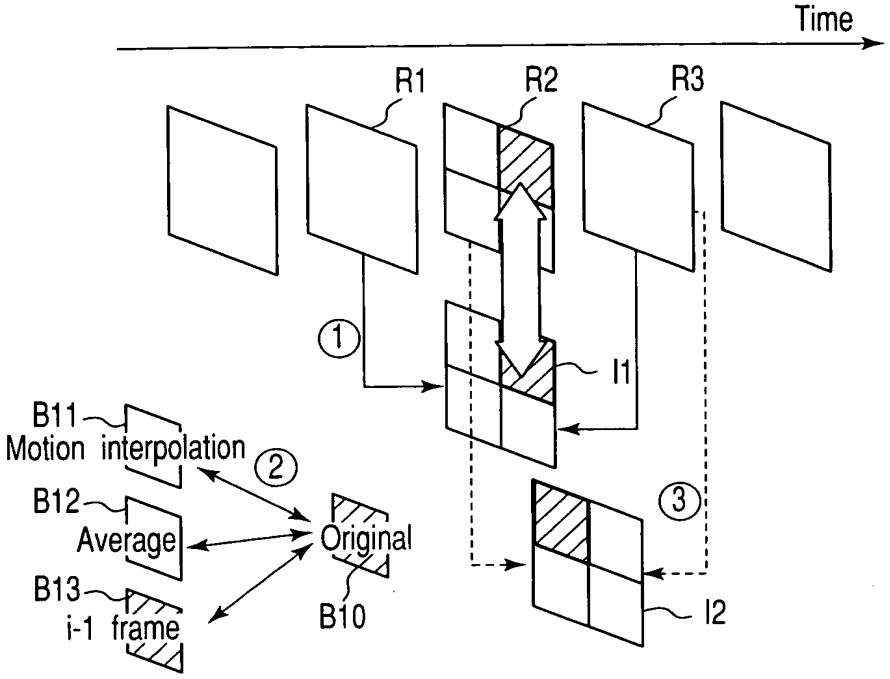
Time
R1
R2
R3
①
I1
B11
Motion interpolation
②
B12
Average
B13
i-1 frame
Original
B10
③
I2

FIG. 21

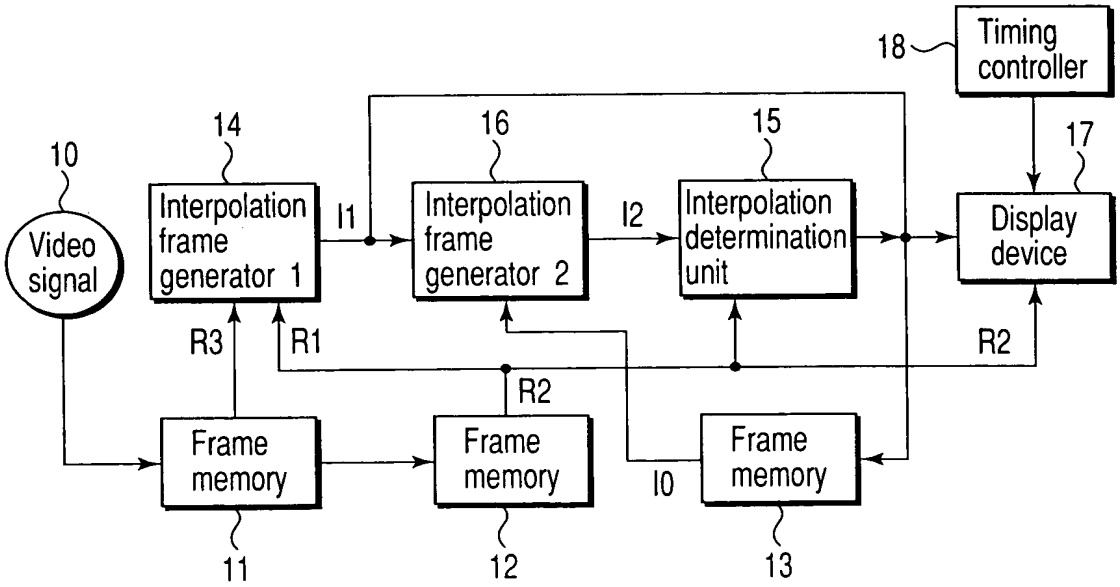
18
Timing controller
17
10
Video signal
14
Interpolation frame generator 1
I1
16
Interpolation frame generator 2
I2
15
Interpolation determination unit
Display device
R3
R1
R2
R2
Frame memory
Frame memory
I0
Frame memory
11
12
13

FIG. 24

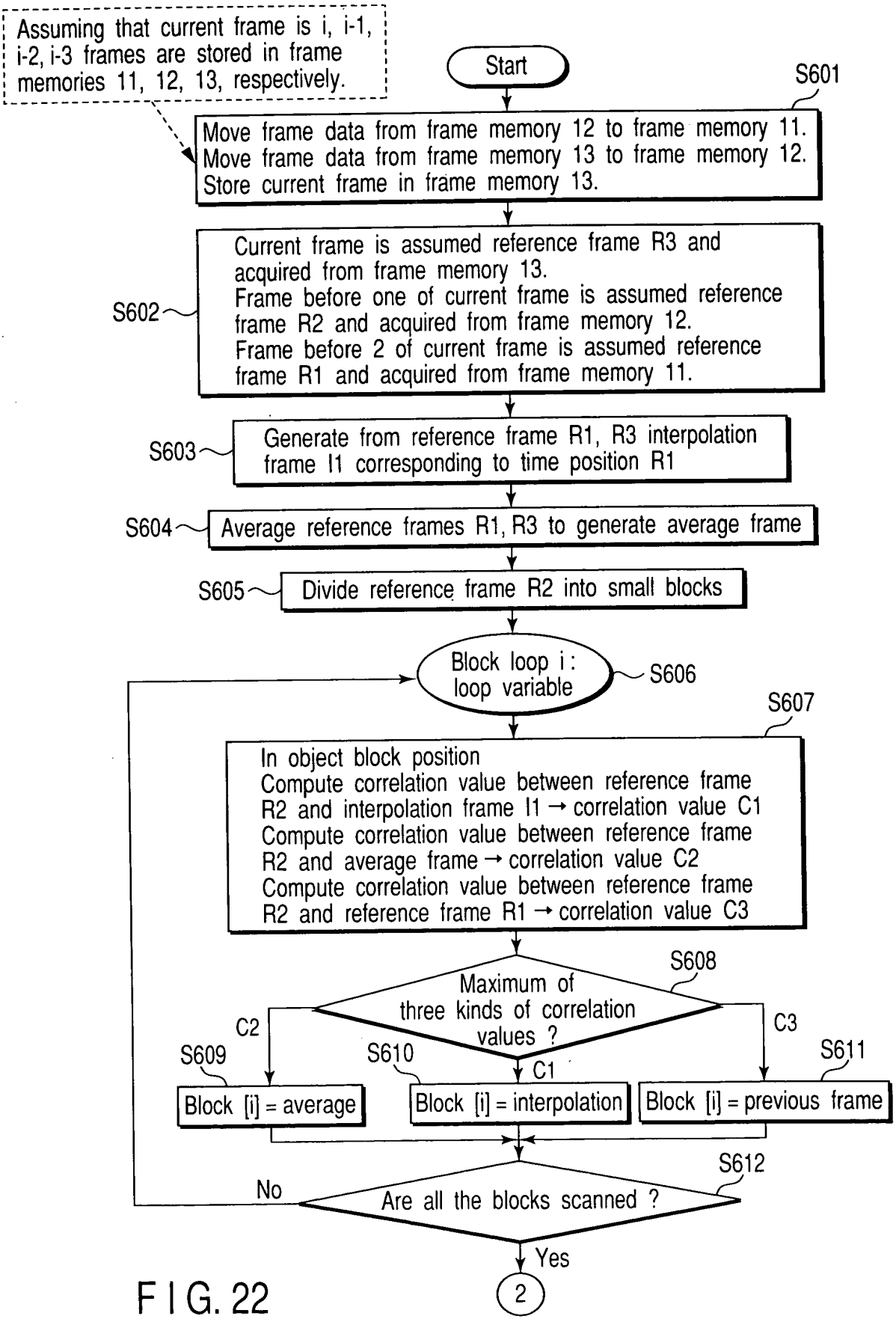
Assuming that current frame is i, i-1, i-2, i-3 frames are stored in frame memories 11, 12, 13, respectively.
Start
S601
Move frame data from frame memory 12 to frame memory 11.
Move frame data from frame memory 13 to frame memory 12.
Store current frame in frame memory 13.
S602
Current frame is assumed reference frame R3 and acquired from frame memory 13.
Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12.
Frame before 2 of current frame is assumed reference frame R1 and acquired from frame memory 11.
S603
Generate from reference frame R1, R3 interpolation frame I1 corresponding to time position R1
S604
Average reference frames R1, R3 to generate average frame
S605
Divide reference frame R2 into small blocks
Block loop i : loop variable
S606
S607
In object block position
Compute correlation value between reference frame R2 and interpolation frame I1 → correlation value C1
Compute correlation value between reference frame R2 and average frame → correlation value C2
Compute correlation value between reference frame R2 and reference frame R1 → correlation value C3
S608
Maximum of three kinds of correlation values ?
C2
C1
C3
S609
S610
S611
Block [i] = average
Block [i] = interpolation
Block [i] = previous frame
S612
No
Are all the blocks scanned ?
Yes
2

FIG. 22

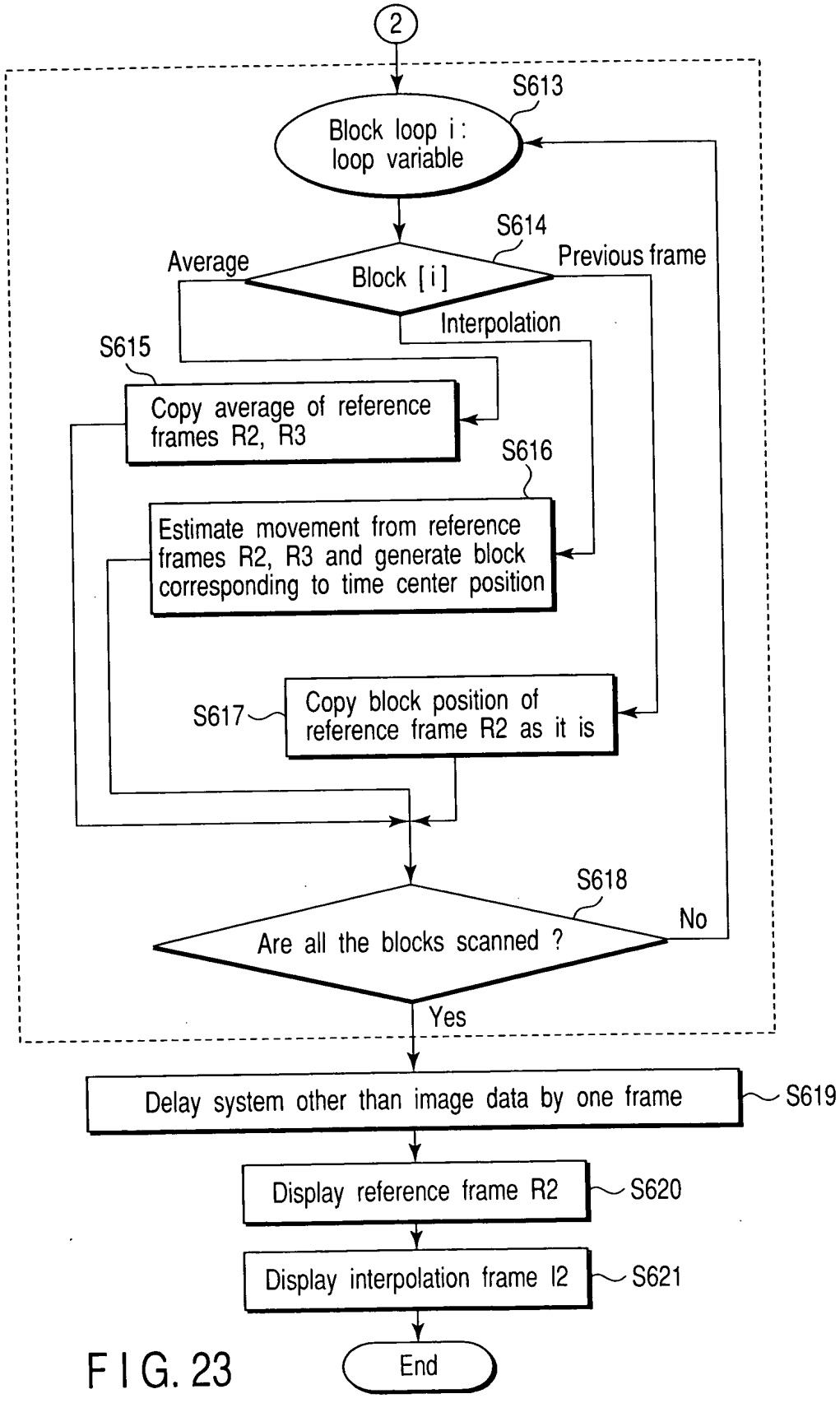
2
S613
Block loop i : loop variable
S614
Average
Block [i]
Previous frame
Interpolation
S615
Copy average of reference frames R2, R3
S616
Estimate movement from reference frames R2, R3 and generate block corresponding to time center position
S617
Copy block position of reference frame R2 as it is
S618
Are all the blocks scanned ?
No
Yes
Delay system other than image data by one frame
S619
Display reference frame R2
S620
Display interpolation frame I2
S621
End

FIG. 23

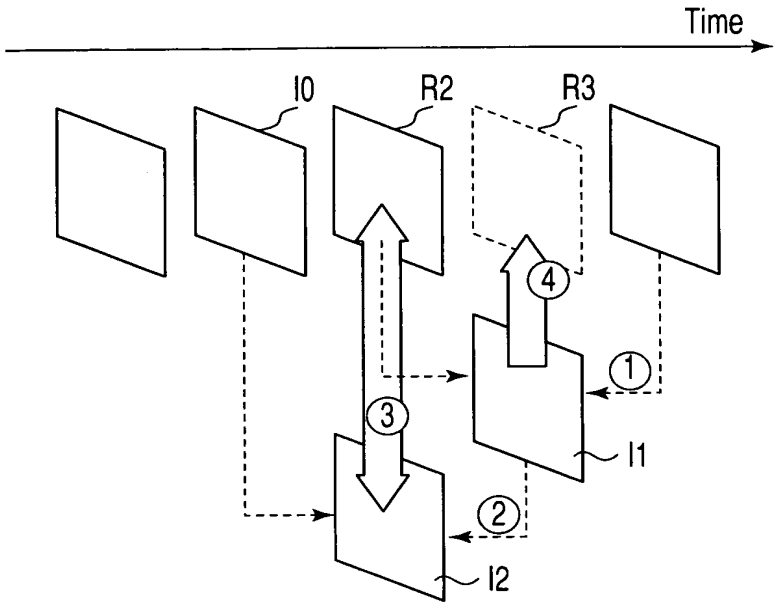
Time
I0
R2
R3
4
1
3
I1
2
I2

FIG. 25

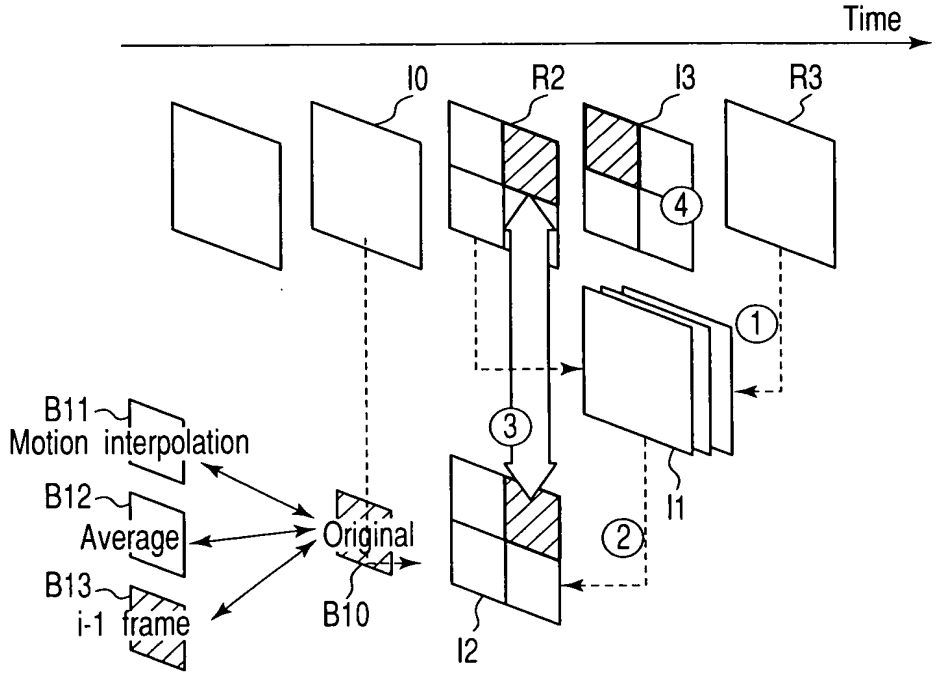
Time
I0
R2
I3
R3
4
1
3
I1
2
I2
B11
Motion interpolation
B12
Average
B13
i-1 frame
Original
B10

FIG. 27

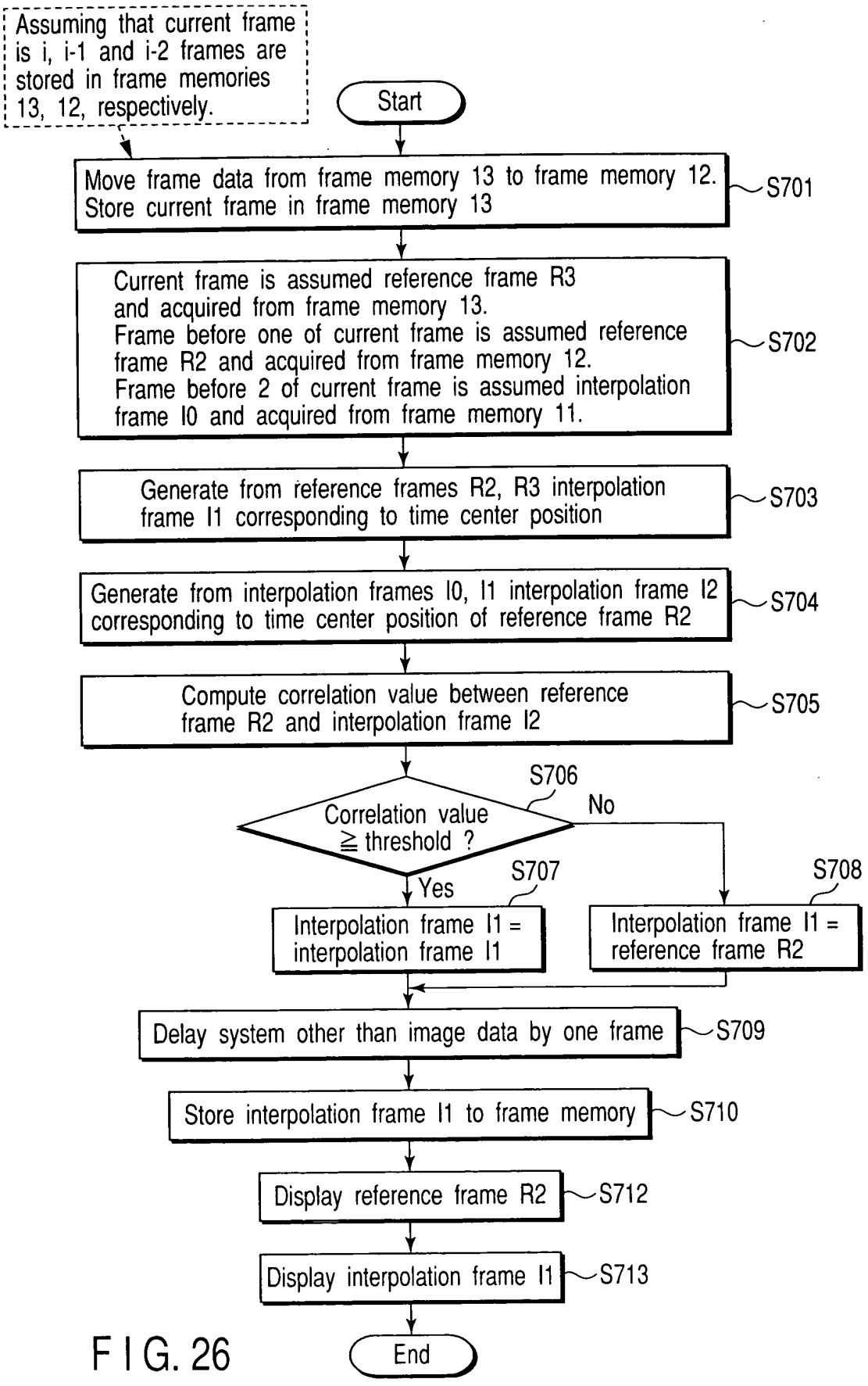
Assuming that current frame is i, i-1 and i-2 frames are stored in frame memories 13, 12, respectively.
Start
Move frame data from frame memory 13 to frame memory 12. Store current frame in frame memory 13
S701
Current frame is assumed reference frame R3 and acquired from frame memory 13. Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12. Frame before 2 of current frame is assumed interpolation frame I0 and acquired from frame memory 11.
S702
Generate from reference frames R2, R3 interpolation frame I1 corresponding to time center position
S703
Generate from interpolation frames I0, I1 interpolation frame I2 corresponding to time center position of reference frame R2
S704
Compute correlation value between reference frame R2 and interpolation frame I2
S705
S706
Correlation value ≧ threshold ?
No
Yes
S707
Interpolation frame I1 = interpolation frame I1
S708
Interpolation frame I1 = reference frame R2
Delay system other than image data by one frame
S709
Store interpolation frame I1 to frame memory
S710
Display reference frame R2
S712
Display interpolation frame I1
S713
End

FIG. 26

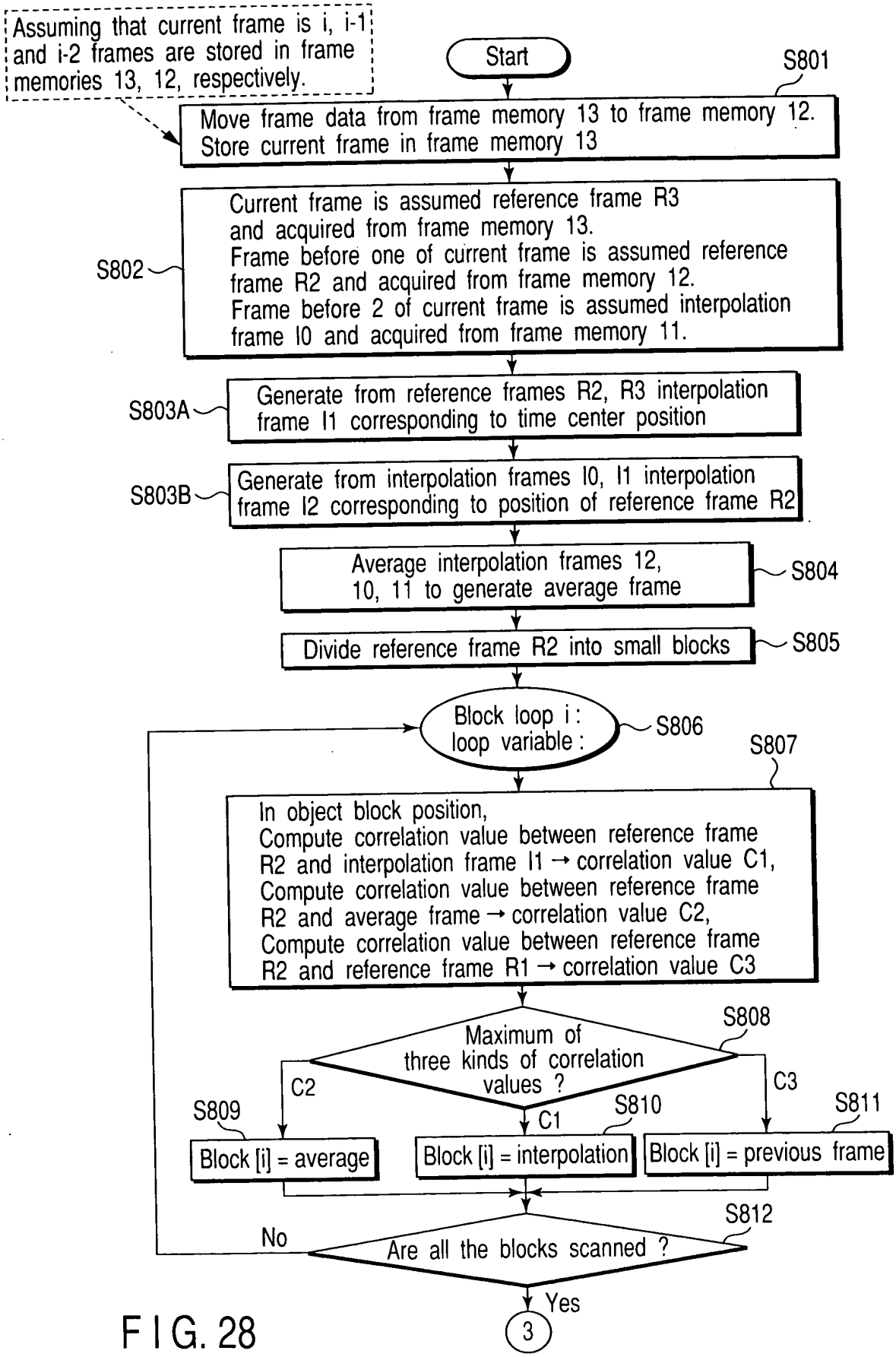
Assuming that current frame is i, i-1 and i-2 frames are stored in frame memories 13, 12, respectively.
Start
S801
Move frame data from frame memory 13 to frame memory 12. Store current frame in frame memory 13
S802
Current frame is assumed reference frame R3 and acquired from frame memory 13. Frame before one of current frame is assumed reference frame R2 and acquired from frame memory 12. Frame before 2 of current frame is assumed interpolation frame I0 and acquired from frame memory 11.
S803A
Generate from reference frames R2, R3 interpolation frame I1 corresponding to time center position
S803B
Generate from interpolation frames I0, I1 interpolation frame I2 corresponding to position of reference frame R2
Average interpolation frames 12, 10, 11 to generate average frame
S804
Divide reference frame R2 into small blocks
S805
Block loop i : loop variable :
S806
S807
In object block position, Compute correlation value between reference frame R2 and interpolation frame I1 → correlation value C1, Compute correlation value between reference frame R2 and average frame → correlation value C2, Compute correlation value between reference frame R2 and reference frame R1 → correlation value C3
S808
Maximum of three kinds of correlation values ?
C2
C1
C3
S809
S810
S811
Block [i] = average
Block [i] = interpolation
Block [i] = previous frame
S812
No
Are all the blocks scanned ?
Yes
3

FIG. 28

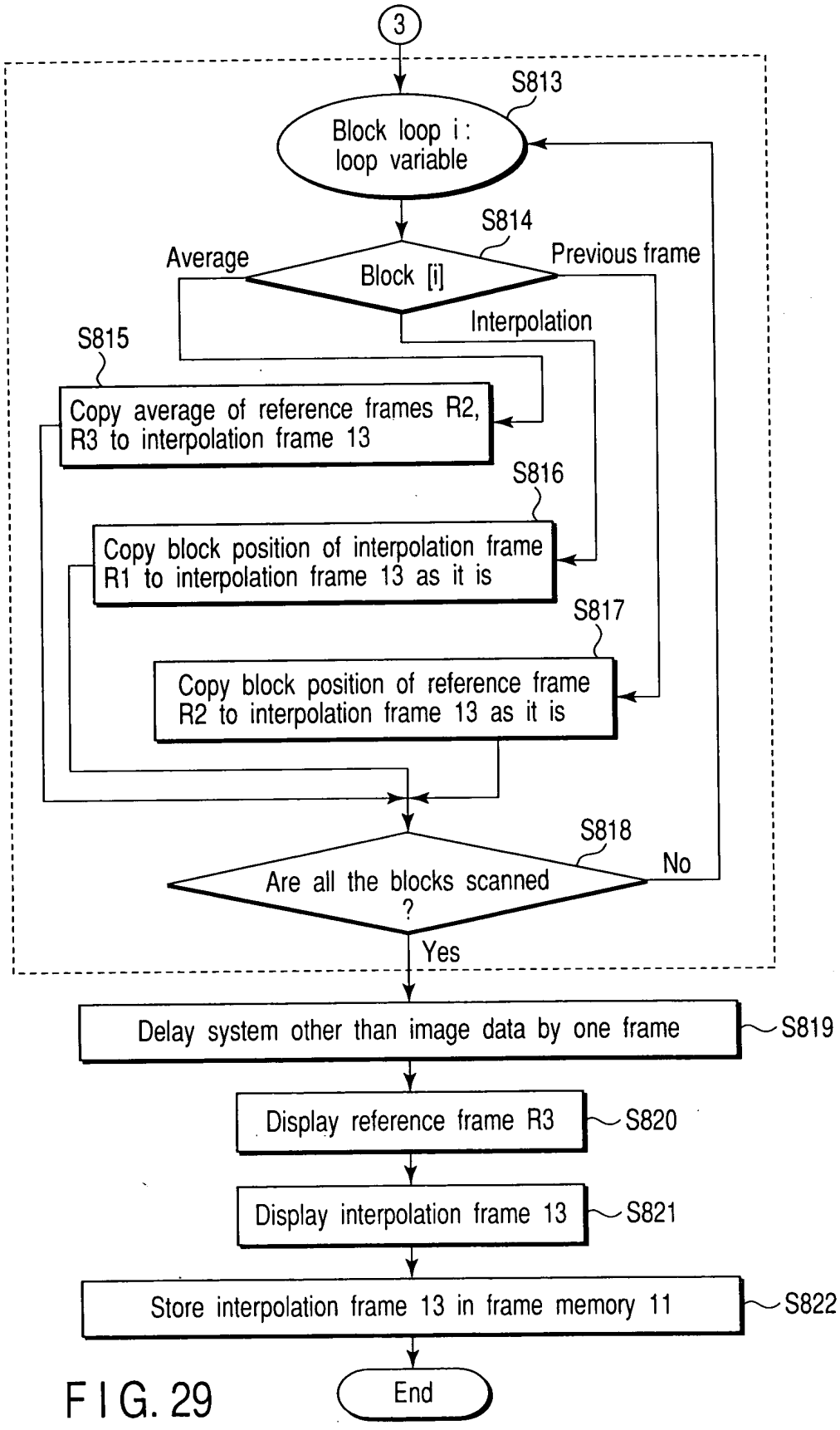
3
S813
Block loop i : loop variable
S814
Average
Block [i]
Previous frame
Interpolation
S815
Copy average of reference frames R2, R3 to interpolation frame 13
S816
Copy block position of interpolation frame R1 to interpolation frame 13 as it is
S817
Copy block position of reference frame R2 to interpolation frame 13 as it is
S818
Are all the blocks scanned ?
No
Yes
Delay system other than image data by one frame
S819
Display reference frame R3
S820
Display interpolation frame 13
S821
Store interpolation frame 13 in frame memory 11
S822
End

FIG. 29